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British Journal of Oral and Maxillofacial Surgery 53 (2015) 607–612

BRITISH Journal of Oral and Maxillofacial Surgery

www.bjoms.com

Effect of the Schneiderian membrane on the formation of bone after lifting the floor of the maxillary sinus: an experimental study in dogs

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Accepted 11 February 2015
Available online 27 May 2015

Abstract

A titanium membrane was used to isolate the Schneiderian membrane of the bony walls of the sinus so that we could investigate their role on the formation of bone after sinus lifts compared with a control group (conventional raising of the sinus floor) in which we did not use a membrane to isolate any area. Three canine models of lifting the sinus floor using the lateral window technique were established: conventional lifting of the floor (control group), raising of the floor with the mucosa shielded (mucosal shielding group), and raising of the floor with the bony wall shielded (bony wall shielding group). The formation of bone one and three months after the sinus floor had been lifted was compared in each group both grossly and by histopathological examination. An appreciable amount of new bone had formed in the control group, with abundant areas near the inferior bony wall, and some near the raised Schneiderian membrane. Similarly, new bone had also formed in the mucosal shielding group, with abundant new bone near the inferior bony wall, but none near the raised Schneiderian membrane. However, there was considerably less new bone in the bony wall shielding group, with none in tissues adjacent to the inferior bony wall and little in tissues near the raised Schneiderian membrane. The Schneiderian membrane has osteogenic capability and participates in the formation of bone after the sinus floor has been lifted. However, its osteogenic role is weaker than that of the surrounding bony wall of the maxillary sinus.
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Keywords: Schneiderian membrane; Maxillary sinus floor elevation; Osteogenesis; Animal study

Introduction

After teeth have been lost from the posterior maxilla there can be insufficient bone for insertion of implants as a result of atrophy and pneumatised maxillary sinuses.[1–4] Raising the floor of the maxillary sinus is an effective solution to this.[5] The Schneiderian membrane is lifted to create a new space between it and the bony floor of the sinus into which a bone graft may be implanted.[6] Clinical reports[7–9] and animal studies have suggested that the Schneiderian membrane promotes formation of new bone in vivo.[10,11] In vitro studies on osteoprogenitor cells in the Schneiderian membrane of humans also support the idea that the Schneiderian membrane has osteogenic potential.[12,13] However, some authors think that the Schneiderian membrane cannot produce new bone after it has been raised.[14,15] There is therefore still debate about whether the Schneiderian membrane plays a part in the formation of new bone after the sinus floor has been raised.

To find out whether the Schneiderian membrane is involved in the formation of new bone, we created models in beagles using the lateral window technique. An ultra-thin titanium membrane was used to block the Schneiderian membrane and bony walls of the sinus, respectively, to compare the amount of bone formed between them, and these were

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http://dx.doi.org/10.1016/j.bjoms.2015.02.010
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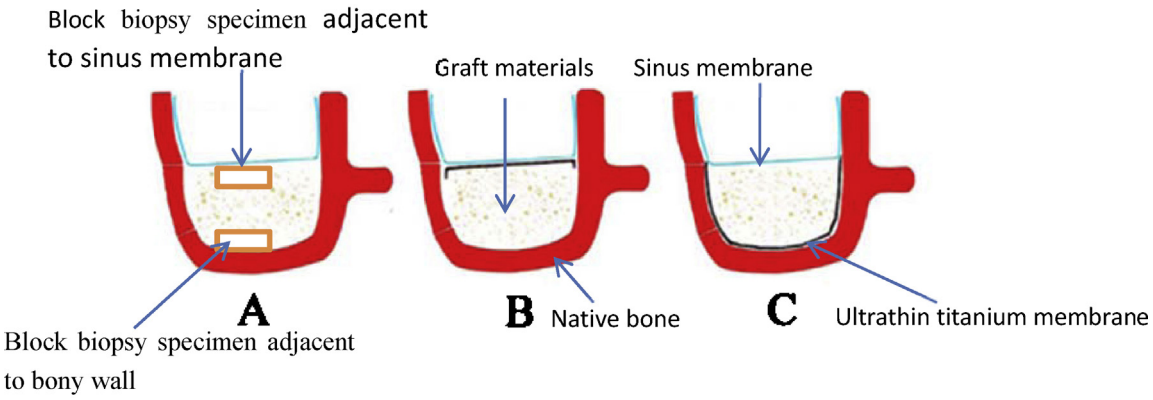

Fig. 1. Diagrams of how the floor of the maxillary sinus was raised. A = the conventional method, B = with mucosal shielding, and C = with bony wall shielding.

compared with a control group, which had conventional lifting of the sinus floor.

Material and methods

Twelve adult female beagle dogs (15–20 kg body weight) were used. The protocol was approved by the Animal Care and Use Committee, Sunyat-Sen University Medical Centre, Guangzhou, PRC. All operations were done under general anaesthesia with ketamine 5 mg/kg and xylazine 2 mg/kg given intramuscularly.

The dogs were divided into three groups of four each. The first (control) group had conventional lifting of the floor of the maxillary sinus alone, the second group had lifting of the floor of the maxillary sinus plus shielding of the mucosa (mucosal shielding group), and the third had the floor of the maxillary sinus raised plus shielding of the bony wall (bony wall shielding group) (Fig. 1).

Surgical technique

The floor of the maxillary sinus was first raised on one side in each dog. A vertical incision was made along the medial maxillary third premolar and distal fourth premolar as far as the vestibular groove, and the mucoperiosteal flap was reflected on the buccal cortical plate. A round burr (2 mm in diameter) was then used to create a window about 20 mm × 8 mm in the buccal side of the maxillary sinus by removing a lamella of bone. The Schneiderian membrane was then carefully dissected and raised about 10 mm, and particles of bone substitute (Bio-Oss®, Geistlich) were implanted in the space created. For the group in which the mucosa was shielded, an ultrathin titanium membrane was shaped and implanted against the Schneiderian membrane after lifting, and Bio-Oss® particles were then implanted. For the group in which the bony wall was shielded, an ultrathin titanium membrane was shaped to fit the surrounding bone walls and placed against them after lifting to block the medial, anterior, posterior and inferior walls. Bio-Oss® particles were then implanted, and the titanium membrane was folded in reverse to lift the buccal side of the created space. Finally, the buccal bony plate was replaced and the mucoperiosteal flap was sutured in place (Fig. 1). Two months after the first operation the same procedure was done on the other side. Gentamicin (80 mg/day) was given intramuscularly for three days after each operation.

Three months after the first operation, the dogs were killed with an overdose of anaesthetic, and samples of the Schneiderian membrane, implanted titanium membrane, Bio-Oss® particles, and newly-formed tissue were examined grossly.

Histopathological examination

The biopsy specimens were evaluated by pathologists who were unaware of which group the specimen came from. Tissue blocks about 3 mm × 3 mm were collected from areas adjacent to the Schneiderian membrane and lower bony wall for examination (Fig. 1). The tissue blocks were fixed in 4% paraformaldehyde for 12 h, decalcified in 5% nitric acid solution for 12–24 h, dehydrated in graded ethanols, embedded in paraffin, and sectioned into tissue slices 4 μm thick. The slices were stained with haematoxylin and eosin and viewed under an optical microscope.

Results

All the Schneiderian membranes were grossly intact with no perforations. The implanted ultrathin titanium membrane was not displaced and contained no perforations.

Control group

One month after the sinus floor had been raised, Bio-Oss® particles were fused with newly-formed bony tissue, though particles of bone were still well-defined. Three months later the Bio-Oss® particles were fused more tightly with newly-formed tissue, and were indistinguishable from the surrounding bony walls. However, there were still particles near the Schneiderian membrane.

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